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FARMERS' BULLETIN No. 1511

FORAGE CROPS AND THEIR CULTURE IN NORTHERN NEBRASKA AND THE DAKOTAS

THIS BULLETIN deals with those cultivated forage crops that seem of greatest promise for the dry-farming districts of northern Nebraska and the Dakotas west of the ninety-eighth meridian. Frequent crop failures in the more arid portions of these States result from a low annual precipitation, the irregularity of its amount and distribution during the growing season, and high evaporation.

Under conditions of extreme drought, cultivated crops can seldom be economically substituted for native vegetation, and the utilization of such lands for grazing and the cutting of wild hay is most generally advisable. Greater forage production on the better lands may be effected by growing certain cultivated legumes, grasses, and roots.

Legumes are valuable forage and soil-improving crops. The use of tilled crops, such as corn and sorghum, are necessary for effective weed control and good soil tilth. Alfalfa and sweet clover are the two most common and generally adapted legumes. The use of hardy varieties is essential. Alfalfa and the perennial grasses are suited to long rotations. Clovers grown in the region are for the most part biennials and are generally sown with nurse crops. Field peas and soy beans are annual hay, pasture, and seed legumes of minor importance, but well suited to short rotations.

The small grains, especially oats and barley, may often be advantageously diverted to hay purposes when a profitable grain yield can not be realized. Millet is a useful emergency hay and pasture crop. Sudan grass is an emergency hay and summer pasture for the more favorable conditions in southern North Dakota and southward. Cultivated perennial grasses are of minor importance, constituting only a very small percentage of the cropping area.

Corn is unexcelled for coarse fodder and silage and is the most economically grown and generally adapted of crops of this nature. Sorgo is more drought resistant than corn and better suited for fodder and silage in western Nebraska and southwestern South Dakota.

Sunflowers are successfully used for silage where the season is too short and cool for corn and sorgo.

Dwarf Essex rape is an excellent emergency mid-season and fall pasture under the more favorable conditions in the eastern fourth of this region.

Root crops, especially mangels, are successfully grown in the more favored locations.

Washington, D. C. Issued April, 1927

FORAGE CROPS AND THEIR CULTURE IN NORTHERN NEBRASKA AND THE DAKOTAS

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SCOPE OF THIS BULLETIN

THE REGION to which this bulletin applies includes North Dakota, South Dakota, and the northern half of Nebraska, comprising an area with widely varying physical features and soils. (Fig. 1.) Climatic conditions are also variable and often erratic, especially as regards precipitation. In the main the region is a level and rolling treeless plain. (Fig. 2.) The portion of these States east of the ninety-eighth meridian, constituting about one-fifth of the area, is practically all arable, productive, and suited to successful agriculture. The dry-farming area west of this meridian, though generally fertile, is subject to frequent drought at critical periods. This condition is so hazardous for cultivated crops that in order to make farming feasible it is necessary to utilize comparatively large areas of land with more or less dependence on native vegetation. Cereals are the major cultivated crops.

Precipitation, temperature, and winds are very important climatic factors affecting crop production. According to data furnished by the Weather Bureau of the United States Department of Agriculture, the average annual precipitation varies in amount from over 30 inches in the southeastern portion of this region to less than 14 inches in certain western districts. (Fig. 1.) About three-fourths of the yearly precipitation occurs within the period from April to September, inclusive. There is sufficient regularity in its amount and distribution in the eastern portion to insure practically the successful growing of crops in a majority of seasons, but in the western portion the uneven distribution of the limited rainfall and great evaporation result in frequent crop failures. The region is also subject to great extremes of temperatures. Those prevailing through spring and fall are generally moderate, but periods of severe cold

occur in winter and intense heat in summer, while all seasons of the year are subject to violent fluctuations. Temperatures above 100° F. are not uncommonly recorded in summer and as low as 20 to 30° F. below zero in winter. The average number of days between killing frost varies from less than 90 to over 160. High winds are of common occurrence and dry out the soil rapidly.

The most valuable adjunct to any system of agriculture adapted to the greater portion of this region is native vegetation. The adaptation of native grasses and legumes to these conditions being proved by their presence, it would seem that the turning by the plow of any large area is justified only after most careful consideration and a thorough testing of cultivated crops on small areas. The problem in handling native-grass lands is to procure the largest quantity of feed possible and at the same time preserve the most valuable plants. Harvesting for hay seems to have only slightly deleterious effects on native vegetation, but excessive grazing tends to eliminate many of the better grasses and results in greater growth of undesirable plants.

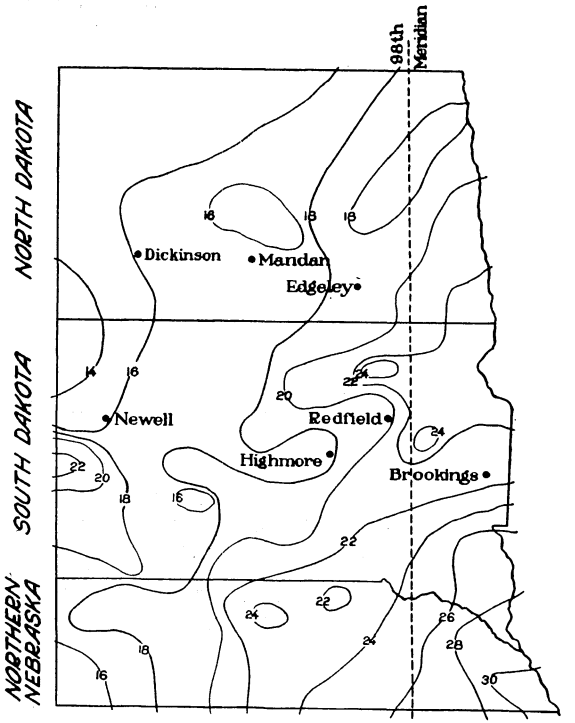

FIG. 1.—Outline map of northern Nebraska and the Dakotas, showing the average annual precipitation (in inches) for different portions of this region. (Prepared with the assistance of the Weather Bureau, United States Department of Agriculture)

The cultivated forage crops that can be successfully grown become fewer in number and of somewhat different character as the rainfall decreases, the growing season becomes shorter, and temperature variations become greater. The methods of culture, however, though varying to some extent, are fundamentally the same. Alfalfa has long been the leading cultivated hay crop in Nebraska. The most marked increase in acreage during the last few years has been in North Dakota and South Dakota. The wide adaptability of sweet clover and its value for pasturage and as a soil-improving crop has become better recognized. Adapted strains of field peas, soy beans, corn, sorghums, sunflowers, millet, Sudan grass, and other cultivated forages are available where such crops have a distinct sphere of usefulness. The purpose of this bulletin is to discuss the most promis-

ing of these forages and their culture and uses for the region in question, using as a basis for conclusions principally the results obtained in the forage-crop field experiments conducted by the Bureau of Plant Industry at the field station at Redfield, S. Dak., during the period from 1914 to 1925, inclusive, but augmented by results obtained in North Dakota at Edgeley, Mandan, and Dickinson, and in South Dakota at Newell, Highmore, and Brookings.

CONDITIONS AT THE REDFIELD FIELD STATION

It will be observed in Figure 1 that Redfield is situated midway between central Nebraska and the Canadian line and 25 miles west of the ninety-eighth meridian, which is regarded as the approximate eastern boundary of the Great Plains region. The station lies

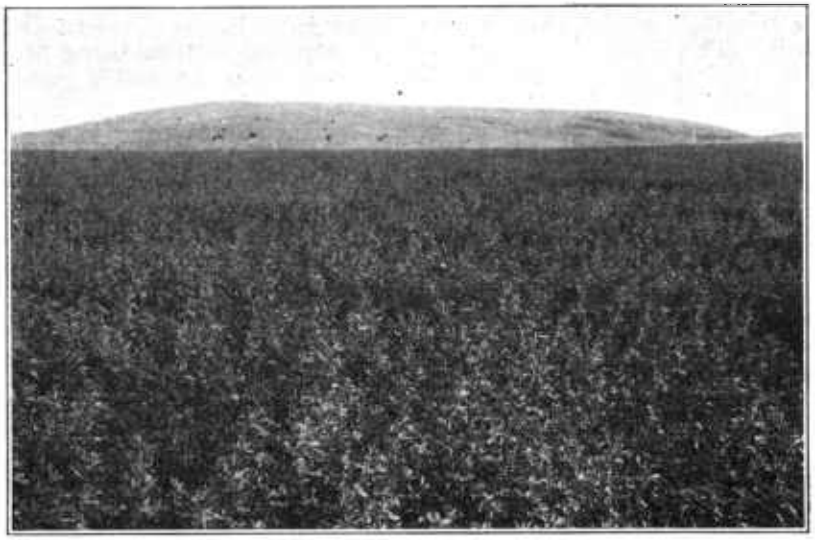

FIG. 2.—Alfalfa is an excellent hay and pasture crop, but in much of the region it makes satisfactory growth only along stream courses or on other low-lying lands where moisture conditions are especially favorable

on slightly rolling prairie land in the valley of the James River, at an elevation of about 1,300 feet above sea level.

The soil of the Redfield field station is of glacial origin and quite representative of a considerable area in the east-central portion of this region. It is productive, well drained, and well supplied with organic matter. In the main it consists of 6 or 8 inches of dark-brown or black clay loam of a friable structure resting upon a dark-brown silty clay loam. At about 18 inches this material is underlain by a light grayish brown heavy silt loam that contains a relatively high percentage of lime and extends to a depth of 4 feet.

The average annual precipitation at Redfield was 20.10 inches over a 25-year period. The average seasonal precipitation, from April to September, inclusive, during this period was 15.52 inches, an amount sufficient for the production of good yields of the important crops, but distribution is generally somewhat uneven, thus making diversified cropping desirable.

At this station the length of the growing season varies greatly, as shown by records extending over a period of 28 years. The frost-free periods range in length from 83 to 172 days, with an average length of 136 days. The average date of the last killing frost in the spring is May 14 and of the first killing frost in the fall is September 27.

The crop yields at the Redfield field station, to which numerous references are made in this bulletin, are better than can be expected under average farming conditions, owing to rotation and thorough tillage.

THE PLACE OF CULTIVATED FORAGE CROPS IN THE CROPPING SYSTEM

Grain farming predominates in the eastern third of this region, and livestock is the chief source of revenue in the western two-thirds. This results in many kinds of cropping systems being practiced, but the general tendency now seems to be toward a greater diversification of crops.

The single-cropping system, which is usually practiced to a considerable extent where grain farming prevails, results in gradually decreasing the productivity of the soil and increasing the tendency toward insect and disease injury. Where such a system has been followed, the productivity of the soil may be improved by the introduction into the rotation of grasses and legumes, the most important of which are brome grass, slender wheat, millet, Sudan grass, alfalfa, clover, and field peas. The use of tilled crops is also necessary for effective weed control and good soil tilth. A coarse fodder and silage crop, such as corn, may well constitute an important part of the cultivated area. Other forages that may be used as tilled crops are sorgo, sunflowers, soy beans, root crops, and rape.

However, the selection of adapted forages suited to the kinds of livestock kept, also the area devoted to each and their place in the cropping system, must necessarily conform to the individual needs and desires of the farmer. Farms devoted to grain are required to grow only a small acreage of forage for their own needs, whereas on livestock farms a considerable area must be devoted to such crops.

Under conditions of extreme drought the production and storage of a certain quantity of surplus forage each season to furnish feed through periods of crop failure is a practice generally recommended.

PREPARATION OF THE SEED BED FOR FORAGE CROPS

Good stands free from weeds are very important essentials in the successful growth of forage crops. This is accomplished by thorough and timely preparation and cultivation.

Crops often show marked differences in behavior with different plowing methods, particularly as regards time and depth of plowing. Time of plowing is a most important factor, better returns being obtained from fall plowing one season and spring plowing another. Experimental data over a period of years, however, tend to show that fall and spring plowing are of about equal value for

most crops under dry-farming conditions if planting is not delayed. The advantages of fall plowing consist in hastening maturity of the crop, more satisfactory labor distribution, more effective destruction of noxious weeds and insects, and the permitting of better frost action on the soil through the winter. Spring plowing of stubble or sod lands for tilled crops is usually the most feasible. Better returns are obtained under many conditions, and the effects of drought are not so quickly apparent on wind-swept fields, owing largely to the catching of snow by stubble or grass during the winter months. Everything considered, early fall plowing is most satisfactory for small grains, field peas, alfalfa, clover, and the perennial grasses, and early spring plowing for corn, sorghum, sunflowers, and beans. Plowing about two weeks before the sowing of such crops as millet and Sudan grass is usually advisable. Allowing for a certain flexibility of this rule—as, for example, the plowing of a larger area in the fall when conditions are unusually favorable—it would seem that little improvement can be made on what available data indicate to be the most feasible farm practice. These data also show that very deep plowing should be done in the fall and the more shallow plowing in the spring.

Spring cultivation should be of such a character as to check weed growth and give a fine mellow seed bed. Disking and harrowing will put the average plowed land in excellent condition for sowing, but when the seed bed is dry or loose some form of corrugated roller or packer may be used to obtain firmness. Fall-plowed land is usually best left in the rough until early spring.

To get best results in sowing alfalfa, clover, and perennial grasses it is essential to have a firm, deep, and clean seed bed. Such a bed is most easily and satisfactorily obtained on stubble or sod lands by selecting soils comparatively free from weeds and plowing deeply in early fall. When necessary to plow in the season that sowing is done, early spring plowing is usually to be preferred to late spring plowing, as it affords greater opportunity for the making of a firm seed bed. Where the soil moisture is favorable good stands are often obtained on late spring plowing. A practicable means of establishing new fields of these crops, especially if sown with a nurse crop, is to sow on corn, sorghum, or soy-bean fields that have been kept free from weeds the preceding season by thorough cultivation. Double disking before and harrowing after sowing lands previously in tilled crops will generally put soils of average texture in good condition.

The seed bed may be prepared for field peas as for alfalfa and clover. It should be plowed deep in the fall, in order that there may be no unnecessary delays in the spring sowing. For sowing with the grain drill the spring preparation should consist of a double disking, but where the seed is broadcast it is better to leave the land rough until sowing time and then cover the seed by disking.

Stubble or sod lands are generally utilized for corn, sorgo, and sunflowers. Under average humid conditions these crops do equally well on fall and spring plowing. Early fall and early spring plowing and the destruction of at least one crop of weeds by disking before planting give the better results. Although a good seed bed is highly desirable for sunflowers, land that does not work down into

good condition for the sowing of other crops can be utilized. Because of the slow early growth of sorgo, the selection of clean land and thorough seed-bed preparation is very essential.

The seed bed for soy beans, tepary, navy, and Great Northern beans is prepared as for corn, but greater care must be taken to leave the land comparatively smooth and free of trash.

The seed bed of small grains for hay or pasture is prepared in a manner identical with that for alfalfa, clover, and the perennial grasses, except that it need not be put in as excellent tilth. Following a tilled crop, land preparation by disking only is usually most profitable.

A well-prepared seed bed gives the best results in growing millet and Sudan grass. If sown after an early sowing of another crop has failed, the seed bed is best prepared with the disk harrow only. Spring plowing is usually more satisfactory than fall plowing on land devoted exclusively to the crop during the season; it should be done at least two weeks before sowing, to afford better opportunity for effective weed destruction. Care should be taken to crush large clods and leave the field smooth, so as not to cause undue difficulty in harvesting.

Mangels, sugar beets, stock carrots, rutabagas, rape, and kale require a clean and fine but not firm seed bed. Soil packing and crusting is a serious factor on heavy soils, and under this condition plowing and harrowing just before sowing are often most satisfactory in establishing a favorable seed bed.

LEGUMES

The leguminous crops of greatest economic promise in this region are alfalfa, sweet clover, soy beans, and field peas. There are other legumes, including common red, mammoth, alsike, and white clovers, navy beans, Great Northern beans, and cowpeas, that are either of little importance or of value in very restricted areas or as a constituent in mixed plantings. An adapted strain of the tepary bean is a promising new legume for a considerable portion of this region. The legume crops will be discussed in such detail as their importance or promise of value under these conditions would seem to justify.

METHOD OF SOWING

The most satisfactory implement for sowing alfalfa and clover, without a nurse crop, is the alfalfa and clover drill. As relatively few growers can afford to purchase a machine of this sort, sowing from the grass-seeder attachment of the grain drill is generally the most practicable method. This implement is also best constructed for sowing alfalfa and clover with nurse crops. It sows the grain at the proper depth, but care must be taken that the alfalfa and clover seed is not covered too deeply. The seed may also be sown broadcast and harrowed in.

Field peas should be sown alone for seed production, but for hay they may be sown alone or with small grain. They may be sown alone with a grain drill if the seed is not too much broken by its use. Where a drill is not available the peas may be sown broadcast on rough plowing and disked in. Field peas should be covered much

deeper than the small grain, and in mixed sowings the most satisfactory means is to perform two operations with the drill or broadcast the seed of the small grain by hand and then drill in the peas.

Soy beans may be planted with a grain drill, using all the seed cups for close plantings and closing part of them for wide spacing. For drilled rows 40 to 44 inches apart a corn planter equipped with special bean plates is very satisfactory. Corn and soy beans are frequently planted together. This can be satisfactorily done with the corn planter provided the seed is first thoroughly mixed and frequently stirred while planting. A bean-planting attachment may be obtained for a number of makes of corn planter that will do excellent work in planting soy beans alone or with corn. A garden drill may be used in planting small areas. For hay, soy beans are broadcast on the rough plowing and then disked in.

INOCULATION

The required bacteria for alfalfa and sweet clover are present in the soil over much of this area, and it is usually unnecessary to supply them through culture mediums. This is not so generally true with beans and peas. On fields that are known or suspected of lacking nitrogen-fixing organisms the introduction of these bacteria by the application of inoculated soil from a field on which the crop has previously grown successfully or by treating the seed with pure cultures is essential. These cultures may be purchased from commercial concerns. Printed instructions are furnished with cultures.

ALFALFA

Alfalfa is the most important of the perennial forage and soil-improving legumes. (Fig. 2.) Under favorable conditions it furnishes one or more cuttings of forage that is fed with good results to all classes of livestock. Having a high protein and mineral content, alfalfa as hay, pasture, or silage is best supplemented in feed rations by corn or other feeds low in these constituents. Alfalfa thrives on a variety of soils and is resistant to the presence of a small amount of alkali. It produces the largest yields, though, on well-drained, deep loams having an abundance of organic matter and lime.

No other perennial crop is capable of making hay returns equal to those of alfalfa. Grimm alfalfa in plots produced an average yield of 2.16 tons to the acre from two cuttings each season during a 7-year period at Redfield. In the more humid parts of this region a somewhat larger tonnage is obtained, while yields decrease as the precipitation becomes less to the westward.

Although of the greatest value for hay, alfalfa may also be utilized for pasturage and silage. It makes especially valuable pasturage for hogs. The usual precautions to prevent bloat must be taken in pasturing cattle and sheep. Alfalfa is seldom economically utilized for silage.

Occasionally seasonal conditions are such that a good seed crop is obtained under dry-farming conditions and a substantial additional revenue realized. The straw will also furnish a good roughage,

especially if the crop is harvested in favorable weather and care exercised in handling and stacking.

Practically all the soils of this region have sufficient lime for the growing of alfalfa, but where there is a deficiency an application of 2,000 pounds per acre should correct the trouble.

VARIETIES

The relative yields of the alfalfas commonly grown in this region do not vary greatly as long as good stands are maintained. For three seasons at Redfield, when stands were practically equal, Grimm alfalfa yielded 2.62 tons per acre, northern-grown common 2.55 tons, and Kansas common 2.43 tons. Over a period of four seasons other plots of Grimm made an average return of 2.01 tons of hay per acre, perceptibly exceeding that of northern-grown common, which made 1.78 tons to the acre, and Kansas common, 1.64 tons to the acre. This difference was due to the thinning out during the winter months of the less hardy strains.

Although resistance to cold is an important factor for this region, it is not the only one. It is the occasionally severe fall and winter drought of long duration that usually eliminates alfalfa, unless the field has been subjected to too frequent or too late cuttings. This is well illustrated in the mortality following the very dry season of 1919 and the winter of 1919–20 when there occurred a reduction in stand of 21 per cent of Grimm alfalfa, 53 per cent of Canadian Variegated, 58 per cent of northern-grown common, and 92 per cent of Kansas common.

Of the large number of varieties of *Medicago sativa* and *M. falcata* and their hybrids that have been tested, the Grimm and northern-grown common are at present of the greatest commercial importance as far as this region is concerned. The Grimm is a hybrid alfalfa of proved hardiness and a good hay-yielding variety. Northern-grown common is more liable to kill out badly under conditions of extreme drought. There are other varieties of promise, including Cossack and Ladak. The Cossack is a hybrid alfalfa that has about equaled Grimm in hardiness and forage production at Redfield. The Ladak is a new hybrid variety first introduced into this country by the United States Department of Agriculture in 1910 from the mountainous regions of northern British India. It is a very promising alfalfa for the dry lands of the northern Great Plains and the northern intermountain sections. It produces a very heavy first cutting of alfalfa, but recovers slowly, thus being of greatest promise where seasons are short and dry. At Redfield it has had a slight advantage over Grimm alfalfa in hay yield and a rather pronounced advantage in seed production.

PLACE IN THE CROPPING SYSTEM

Alfalfa is best suited to a long rotation, but figures obtained at Redfield tend to show that the productive capacity of the crop is greatest during the second, third, and fourth seasons, whether it is utilized for hay or for seed. Yields over a series of years indicate that fields can usually be the more profitably returned to cultivated

crops at the end of the fifth or sixth season, unless the alfalfa is of a valuable strain from which it is desired to obtain seed.

Alfalfa follows best a tilled crop, although there is no reason why it can not be sown on clean land after small grain or any other crop, provided the soil is properly prepared. Alfalfa exhausts the soil of its moisture during periods of drought, and unless there is an abundance of rainfall the yields of the following crop will be much reduced. This is shown in potato yields at Redfield for four years. Early Ohio potatoes after alfalfa gave an average yield of 207 bushels to the acre and after corn 193.7 bushels. Under identical growing conditions Rural New Yorker, a late-maturing variety, yielded 133.8 bushels after alfalfa and 143.4 bushels after corn. It is therefore advisable to use early-maturing potatoes the first year after alfalfa, as they are less affected by lack of moisture resulting from the demands of alfalfa the previous season. The assertion is often made that there is a tendency for potatoes grown on alfalfa ground to be scabby, but no trouble of this sort has been observed in the experiments at Redfield.

The best means of eradicating alfalfa from fields being returned to cultivation is to plow 3½ to 4 inches deep with a sharp plow, using plenty of horsepower. The most desirable time is after the last crop of the season has been harvested, or as soon thereafter as soil conditions will permit. Shallow fall plowing will sever alfalfa roots just below the crown and expose them to winter conditions, and when followed by deep spring plowing most of the plants will be killed. The grower of alfalfa, however, is seldom so fortunate as to be able to choose the most opportune time for plowing. Because of dryness of the soil it may be necessary to delay plowing until early spring. Though this may result in considerable volunteering, ordinarily such plants will not be sufficiently numerous to offer any serious difficulty. At Redfield alfalfa has been effectively destroyed by plowing about May 1, which still gives ample time to prepare the land for planting corn. This is not practicable under dry-farming conditions.

It has been found that frequent and late cuttings result in greater mortality the following winter, and for this reason the grower is justified in pasturing a field very closely in the fall or cutting it frequently for hay the last year that the field is to be in alfalfa.

OBTAINING STANDS FREE OF WEEDS

Before sowing alfalfa an effort should be made to destroy as many of the weed seeds as possible. The use of clean-cultivated crops previous to sowing alfalfa will be of considerable assistance in this respect. Under dry-farming conditions annual weeds are very troublesome the first season, but at Redfield they have not interfered appreciably with getting stands. Efforts to hold the weeds in check by clipping during the first season have not benefited the alfalfa. The yields the following season from clipped plots of Grimm alfalfa over a period of four years have averaged 1.90 tons to the acre as compared with 2.05 tons from nonclipped plots. A practice that has given good results at Redfield is to leave the field untreated the first year and in case of a dense covering of dead weeds to burn it

over the following spring before alfalfa starts to grow. Cultivation with a spring-tooth or disk harrow in early spring may at times be employed in destroying weed seedlings in thin stands, but good stands of alfalfa will soon smother foreign plants, except such perennial grasses as awnless brome and blue grass.

TIME, RATE, AND DEPTH OF SOWING

There is a considerable latitude of time during which alfalfa may be sown without a nurse crop. Good stands have been obtained for a number of years at Redfield from sowings made any time between April 10 and June 6, but it has usually proved advisable to sow as soon in the spring as temperature and moisture conditions are favorable. The optimum period in the southern portion of this region is somewhat earlier, whereas in the northern locations it is later. Plants of early sowings are larger and have a much better developed root system when drought and weed growth are most pronounced, and are thus in much better condition for overcoming unfavorable summer conditions. The probability of establishing stands on heavy soils after early June rapidly decreases, because of the likelihood of the soil packing and crusting by heavy rains or the injury of seedlings by hot winds and intense heat. Sowings of alfalfa with nurse crops are made at the proper time for sowing the nurse crop, which is usually as early as the seed bed for the various small grains can be put in proper tilth.

Perfect stands of alfalfa in close-drill plantings have been obtained at Redfield from sowing 5 pounds of seed to the acre, and hay yields over a series of years were practically equal to those from heavier rates of sowing. Under average field conditions it is safer to sow 8 to 12 pounds to the acre. The rate of sowing in cultivated rows may vary from 2 to 3 pounds to the acre, depending upon the distance between the rows and the thickness of stand desired. At times of extreme drought, close spacing of plants tends to increase mortality, but under normal conditions plants afford protection to one another, and close spacing results in less winter injury. In sowing with a nurse crop, 3 pecks of wheat, 5 of oats, 4 of barley, and 20 pounds of flax have given satisfactory results in plots at Redfield. A lighter rate of sowing of the nurse crop is advisable under more arid conditions.

The seed should be sown as shallow as possible and still have it in moist soil. This will be at a depth of from one-half to three-fourths of an inch in soils of average texture.

NURSE CROPS

In actual practice better stands are assured and heavier hay yields are obtained the following year where alfalfa is sown without a nurse crop. At Redfield good stands have been obtained every year for eight years by sowing alone, and with wheat, oats, and barley as nurse crops in only five out of eight years. The average yield per acre of the first cutting of Grimm alfalfa sown alone during the period was 1.59 tons, with wheat 1.30 tons, with oats 1.27 tons, and with barley 1.24 tons.

Flax has proved to be the most satisfactory nurse crop at Redfield, the yields of alfalfa hay being almost as great as where the alfalfa was sown alone. Wheat as a nurse crop has proved slightly less injurious than oats or barley, which were more unsatisfactory because of the greater danger from lodging, thus smothering many of the young alfalfa plants. It is probable that the latter danger may be largely avoided by the use of short-growing and early-maturing varieties.

Where soil and moisture conditions permit, as in the eastern fourth of northern Nebraska and the Dakotas, the most economical means of sowing alfalfa is with a nurse crop, but under dry-farming conditions in the western three-fourths of these States the use of a nurse crop, except possibly flax, is not generally advisable.

GROWING IN ROWS

It is questionable if alfalfa can be economically grown in widely spaced drilled rows in any portion of this region. Yields from close sowings are consistently greater, except where the annual rainfall is 15 inches or less. Even there the tonnage difference in favor of widely spaced rows is hardly sufficient to pay for the added cost of production. This method has somewhat greater merit for seed production where the price warrants.

CULTIVATION

Positive benefits have not been derived from the cultivation of close-drilled or broadcast sowings of alfalfa with a disk or spring-tooth harrow over a period of nine years at Redfield. The lowest average seasonal hay yield was 1.78 tons to the acre and was obtained from plots cultivated twice each season with the disk. The highest average seasonal yield, 1.88 tons to the acre, was obtained from plots cultivated with a disk once in early spring. Plots not cultivated gave an average yield of 1.87 tons to the acre. The slight differences in yields do not justify the conclusion that any particular treatment was sufficiently beneficial to increase hay returns.

The cultivation of alfalfa in early spring causes little injury to alfalfa plants, and in the seasons of early drought it appears that some benefits are derived, but not enough to pay for the increased cost. Injury to plants, though, results from midseason and late season cultivation. In the experiments at Redfield the disk has proved more injurious to plants than the spring-tooth harrow.

HAY PRODUCTION

The best time for harvesting alfalfa for hay is when plants are coming well into flower. Care must be exercised, in order to maintain alfalfa stands, not to harvest too often or so late in the season that new growth will not be sufficient to afford protection to plants throughout the winter. This is especially important at times of severe drought. That numerous cuttings materially increase plant mortality was indicated in results with Grimm alfalfa at Redfield over a period of five years, when harvesting for hay one time each season caused no apparent reduction in stand, but harvesting two

times resulted in an estimated mortality of 12 per cent, and three times 23 per cent. There was also an injury to plants that can not be shown in mortality percentages. Similar and equally conclusive results were shown in the reductions in stands in less extensive plantings during a preceding 4-year period.

At Redfield the results indicate the inadvisability of harvesting more than twice for hay under most conditions or later than September 1 unless there is an abundance of soil moisture.

PASTURING

Alfalfa should not be pastured before the second season and preferably not until the third season. Neither should stock be turned on the field in early spring or late fall or when the ground is very wet. Intensive grazing should be avoided at all times. By dividing the field into two or three fenced areas and then transferring stock from one field to another as the pasture becomes short, the danger of injury from trampling and close grazing will be greatly reduced.

SEED PRODUCTION

The most dependable seed-producing portion of this area is in the vicinity of the Black Hills. Fair yields of seed are also obtained in locations favored with a more dependable moisture supply, particularly in the subsoil, as, for instance, on river and creek bottoms or around the shores of lakes. Over most of the region the alfalfa seed crop is very erratic, owing to various factors, but particularly the moisture supply.

The most desirable stage at which to harvest alfalfa for seed is when about 75 per cent of the pods are brown, but the best time will depend on weather conditions and time of season. When it is desired to obtain good straw roughage, or the weather is unfavorable for proper maturity, it may be necessary to harvest while a much larger percentage of the seed pods are still green.

The mower with bunching and dropping attachment is usually the most convenient implement for harvesting the seed. The self-rake reaper or grain binder may also be used satisfactorily. If care is exercised in handling there is little danger of a large amount of shattering.

Two of the most objectionable adulterants in alfalfa seed are dodder and sweet clover, plants of which mature at about the same time as those of alfalfa. Alfalfa will not completely crowd out sweet clover in fields harvested for seed, and no practical way has been devised to separate the seeds. Areas in which dodder occurs should never be harvested for seed, but should be utilized for hay or pasture. Increasing difficulties are being experienced with sweet clover. A few sweet-clover plants may be removed by hand, but their occurrence in quantity will necessitate the harvesting of the alfalfa for hay until the clover plants disappear. It is also desirable to prevent sweet-clover plants from seeding in the immediate vicinity of the alfalfa field.

Pigeon grass often volunteers in fields, but this weed is not a serious factor, as it persists only where stands are thin, and its seed

can be completely removed by the cleaning machinery now employed.

SWEET CLOVER

Sweet clover is one of the most widely adapted of the cultivated legumes. (Fig. 3.) It is primarily a pasture and soil-improving crop, but the hay harvested at the proper stage and put up in perfect condition has a composition and feeding value approaching alfalfa. The crop does best on well-drained loams that are well supplied with lime. It is hardy and generally suited to the greater portion of this region, withstanding extreme cold and severe drought.

The belief prevails that sweet clover is more resistant to cold and drought than alfalfa, but results at Redfield indicate that under the better soil conditions the white-flowered varieties are not always as

FIG. 3.—Sweet clover is one of the best pasture crops for most of the region and is also valuable as a soil-improving crop. Because of its ability to thrive under less favorable soil conditions than alfalfa, it has a somewhat wider adaptation

hardy as the best strains of alfalfa. Contrary to the belief of many, good stands of alfalfa are obtained with as great ease and the crop grown with equal assurance of success. It would thus seem that sweet clover is to be preferred to alfalfa only as a crop for a short rotation, the pasturing of certain kinds of livestock, as a green-manure crop, and for growing on less favorable soils.

Under favorable soil and moisture conditions sweet clover will produce large yields of hay. The average annual yield when sown without a nurse crop at Redfield, for a period of nine years, was 1.7 tons to the acre. Where grown for hay no crop is ordinarily obtained the first year unless moisture conditions are unusually favorable.

Sweet clover is an extremely valuable pasture plant. After stock become accustomed to the taste they seem to eat it with relish. Under ordinary conditions there seems to be no great danger from

bloat, but in certain seasons, as, for instance, in 1924, the cases of bloat for unexplained reasons were unusually numerous.

Sweet clover has a very beneficial effect on the soil, and no other crop leaves it in more excellent physical condition.

VARIETIES

There are two kinds of sweet clover of importance in this region—the biennial white and the biennial yellow. Except in the drier and colder sections the biennial white is by far the most important of the sweet clovers, and that variety will be considered in detail in this bulletin, but the cultural methods here described apply equally well to all the biennial sweet clovers. The common yellow-flowered variety is lower growing and finer stemmed than the white, but usually furnishes less forage. Hubam, a relatively new annual white sweet clover, has not given much promise in the tests at Redfield.

A number of strains of white sweet clover from different parts of the country have been grown at the Redfield station, but no striking differences in hardiness or yields were observed.

PLACE IN THE CROPPING SYSTEM

Sweet clover is well adapted to either short or long rotations, largely replacing red, mammoth, and alsike clovers on soils and in climates unsuited to the growing of these crops.

Sweet clover follows best a tilled crop, such as corn, but may be sown on clean land after other crops with almost equal assurance of success. If used for green manure in the sections of abundant rainfall sweet-clover fields are plowed in the spring of the second year and usually after considerable plant growth has been made and just in time for corn plantings. When the crop is used for forage and seed, the second-year plowing is deferred until the third year. A tilled crop generally follows sweet clover most advantageously.

Considerable volunteering of sweet clover in succeeding crops generally occurs, often extending over a period of several years. At Redfield, thick stands have been obtained from seed that has remained in the ground three and four seasons, the land in the meantime having been in clean-cultivated crops. A few sweet-clover plants in the field are unsightly, though not generally detrimental, but there are times, as, for instance, in the production of alfalfa, red clover, or millet seed, when a mixture of sweet clover is highly undesirable. Sweet clover plowed in the fall of the first year commonly volunteers considerably the following year. The crowns with 3 or 4 inches of root are buried and many of them put forth new branch roots and a vigorous top growth the following spring. Consequently plowing should be delayed until growth is well started in the spring.

OBTAINING STANDS FREE OF WEEDS

Land that has previously been handled so as to destroy much of the weed growth is highly desirable. After the sweet clover is sown little further attention is usually required the first year. If the weeds prove troublesome the crop may be mowed just before the weed seeds

become viable. Cutting or grazing the first season helps to hold the weeds in check and furnishes a forage for livestock. To avoid injury to the sweet clover and afford some winter protection, the stubble should be left rather high. Where there is a large quantity of dead plant growth on the ground in the spring the field may be burned over while the sweet clover is still dormant without injuring it.

TIME, RATE, AND DEPTH OF SOWING

Sweet clover may be sown from the earliest date that it is possible to get the land in shape to the middle or the last of May. The moisture conditions are usually more favorable for the earlier sowing, but the weeds are less troublesome later. Where a nurse crop is used, sowings are made about the date that has proved best for the nurse crop.

The rate of sowing sweet clover may properly vary from 8 to 16 pounds of hulled seed to the acre. Less seed is required if it is scarified, as such seed germinates quicker and more uniformly. However, seed should not be scarified until the year it is to be sown. At Redfield a satisfactory rate of sowing wheat as a nurse crop is 3 pecks to the acre, oats 5 pecks, and barley 4 pecks.

The depth of sowing is from one-half to 1 inch, the shallower plantings being advisable on moist and heavy soils.

NURSE CROPS

At Redfield, where rainfall is usually rather limited, stands of sweet clover have been obtained in seven out of nine seasons when sown alone and in six out of nine seasons when sown with a nurse crop. Over a period of nine years sweet clover sown alone gave an average yield the year following sowing of 1.7 tons of hay to the acre, with wheat 1.29 tons, with oats 1.2 tons, and with barley 1.01 tons. These figures show that failures to obtain a stand are less frequent and better yields are obtained when sweet clover is sown alone. The difference in average yields over a period of years, however, is hardly sufficient to offset the failure to get any return from the land the year the seed is sown. Owing to the relatively short time that land is occupied by sweet clover, it thus seems that sowing with a nurse crop is much more desirable than is the case with alfalfa.

HAY PRODUCTION

Sweet clover should preferably be cut just before the first flowers appear and at a height not exceeding 30 inches. If allowed to stand too long the stems become woody and many of the leaves are lost, thus reducing the feeding value of the hay. Because of the coarseness of the stems, sweet clover is much slower to cure than alfalfa or red clover.

If it is desired to cut the second crop for seed, a stubble of 6 or 7 inches should be left.

PASTURING

Sweet clover sown in the spring ordinarily furnishes some pasture in the fall, but close grazing should be avoided. The second year it

starts off early and furnishes considerable grazing throughout the season. By dividing the field and grazing the parts alternately, thus allowing opportunity for reseeding, good pastures have been maintained several years.

SEED PRODUCTION

Sweet clover is a liberal producer of seed over practically all of the cultivated portion of this region. From 6 to 8 bushels to the acre is considered a good yield. At the Redfield station as much as 22 bushels to the acre have been produced, but this was in a very favorable season and in widely spaced cultivated rows.

As the seed ripens unevenly, it should be harvested when the greatest yield can be obtained. This is usually when about three-fourths of the pods have turned dark brown to black. If the machinery used causes considerable shattering, the sweet clover should be harvested before it is too mature, or early in the morning while it is still wet with dew. The grain header may be used for harvesting, but the grain or corn binders are more satisfactory.

OTHER CLOVERS

The common red, mammoth, alsike, and white clovers are of importance only in restricted areas. Their culture is similar to that described for sweet clover.

The common red and mammoth clovers require abundant moisture and therefore succeed only in the eastern part of the region or where water is available for irrigation. They are of little value as dryland crops. Their forage is of excellent quality, although not usually equal to alfalfa or sweet clover in yield. Sown alone, 8 to 12 pounds of seed per acre are required. A large proportion of the red-clover sowings are in combination with perennial grasses and other clovers.

Alsike clover is valuable for hay and pasture mixtures and suited to low wet lands on which red clover will not thrive. Plants generally live from two to three years.

The low-growing perennial white clover is well suited for pasture and lawn mixtures. It is very hardy, withstanding close grazing, and small quantities of seed may be added with profit to plantings on soils retentive of moisture.

FIELD PEAS

The field pea is an annual legume well suited to high altitudes and climates too cool for corn. (Fig. 4.) It is valuable for hay and pasturage and for soil improvement. The crop is successfully grown east of the ninety-eighth meridian and north of the Corn Belt proper, but being easily injured by hot winds and drought, it is not well adapted to the dry-farming districts. The chief drawback to the extensive use of the field pea, under the conditions to which it is adapted, is the large quantity of seed required to the acre, which makes the cost of sowing rather high. The soil requirements of the field pea are similar to those of other legumes. They produce maximum yields on deep, rich, well-drained loams, high in lime content.

Field-pea hay has a high nutritive value, approximating that of alfalfa and clover. It may be economically used in feeding all kinds of livestock, but more especially sheep and dairy cows. The average annual yield of field-cured hay of two well-known varieties at Redfield over a period of 10 seasons was 1.57 tons to the acre. Sowings of field peas with oats, where soil and moisture conditions are favorable, return large yields of excellent hay. The small grain furnishes a support for the vines, making the hay easier to harvest, cure, and stack. The average yield of a mixed sowing of field peas and oats at Redfield for a period of three seasons was 2.31 tons of air-dry hay to the acre. For the same period field peas alone gave an average yield of 1.79 tons and oats alone 2.96 tons.

Field peas sown alone or with oats furnish a very satisfactory emergency pasture for hogs and sheep, but owing to the greater injury from trampling they are not so well suited to grazing by

FIG. 4.—The field pea is an annual hay, pasture, and grain crop well suited to cool and moist climates

larger animals. As with other legumes, stock should be accustomed gradually to a field-pea pasture and all possible precautions taken to prevent bloat.

Field-pea grain is a valuable protein concentrate. It is recommended for use in a grain ration for horses, sheep, hogs, and beef and dairy cattle. With the possible exception of hogs, all classes of livestock require the grinding of the seed for the best results in feeding.

At Redfield the yields have varied greatly with the season. In 1923, for example, one variety yielded 41 bushels to the acre, but the average yield of the same variety over a period of eight years was 15 bushels.

When harvested in season and properly stacked, pea straw furnishes a palatable roughage that is much superior to grain straw.

Field peas benefit the soil to some extent, as do other legumes. They can not usually be used as a green-manure crop in the dry-

farming districts, but they constitute one of the most valuable crops for this purpose under irrigation or conditions of abundant rainfall.

VARIETIES

In seasons of early drought early-maturing varieties of field peas, such as French June, do better than the later varieties and are best suited to the central and western portions of this region. Medium-early varieties, like Golden Vine and Kaiser, are heavy yielders of forage and seed and are more generally adapted to growing in the eastern fifth of these States. For sowing with small grain it is highly desirable to select varieties of each crop that will reach the proper stage of maturity at nearly the same time.

The better known northern varieties of field peas have all done well at Redfield. Over a period of nine seasons Golden Vine, Kaiser, and French June each gave an average yield of 1.5 tons of hay to the acre. The Paragon field pea over a period of five years slightly exceeded in average hay yield those of the above-listed varieties. The average seed yields of these varieties per acre for an eight-year period were as follows: Golden Vine, 15 bushels; Kaiser, 15.1 bushels; French June, 13.9 bushels.

PLACE IN THE CROPPING SYSTEM

Field peas may usually be grown to best advantage after hay or small grain, but will satisfactorily follow most other crops if the seed bed can be properly prepared for early spring sowing. Nearly all crops do well after field peas. At Redfield land that has grown field peas the previous season has proved especially good for growing field beans, root crops, rape, kale, and other crops liable to injury from early soil packing and crusting.

TIME, RATE, AND DEPTH OF SOWING

Field peas, either alone or with small grain, should be sown as early as the seed bed can be prepared. Early sowing is especially important for seed production.

The rates of sowing such small-seeded varieties as French June and Golden Vine are from 90 pounds to the acre under dry-farming conditions to 120 pounds to the acre where moisture is more abundant, and large-seeded varieties, like the Kaiser, are sown at rates of from 120 to 150 pounds to the acre. Oats are usually the most desirable of the small grains for sowing with field peas, but beardless barley is well adapted for delayed sowings. From 50 to 70 pounds of field peas and 1 to 1½ bushels of oats or barley approximate the rates of sowings for mixed plantings, the lighter sowings being advisable under the more arid conditions.

The depth of sowing varies from 2 inches on heavy and moist soils to 4 inches on light sandy soils where there is a lack of surface moisture.

HAY AND SILAGE PRODUCTION

Field peas sown alone should be harvested for hay when the pods are well filled. When sown in mixture with oats and barley they

should be harvested when the small grain is in the early dough stage, regardless of how far the peas have developed in the pods. Peas intended for silage may be allowed to reach a somewhat more mature stage.

The harvesting of large areas of field peas will justify the purchase of an attachment for the mower, consisting of guards which extend forward from the cutter bar and lift the vines, thus permitting the bar to pass underneath. The windrow attachment to remove the peas from the swath is also a decided help. The hay crop is handled in much the same way as other legume hays.

PASTURING

To insure rapid gains for fattening animals, they should be fed grain and moved to new fields as pasturage becomes short, using stock animals to clean up what is left. Stock may also be confined to one portion of the field by the use of portable fences and the pastured area increased as necessary to afford continuous feed.

SEED PRODUCTION

Field peas are allowed to stand for seed until the pods are mature and the seed fairly hard. Cutting must be done before the vines are dry to prevent any great amount of shattering. A mower with a bunching or windrowing attachment should be used to reduce handling and the consequent shattering to the minimum.

Small quantities of field peas may be threshed by flailing or trampling. The pea and bean thresher is best suited for the threshing of large quantities, but since such machines are not usually available, the ordinary grain separator is employed for this purpose. To reduce the cracking of the seeds to a minimum, all except one row of four teeth should be removed from the concaves and the cylinder run at low speed, at the same time maintaining the speed of the fans and other parts of the separator. This may be accomplished by doubling the size of both cylinder pulleys.

SOY BEANS

The soy bean is an annual legume utilized for hay, silage, pasture, and as a protein concentrate for livestock. (Fig. 5.) It is easily grown, and when properly cultivated leaves the soil in excellent physical condition for subsequent crops. The soil and climatic requirements are similar to those for corn. The soy bean is grown for both pasture and seed production in the more humid parts of eastern Nebraska and eastern South Dakota, but in southeastern North Dakota its use is confined largely to pasturage. It may also be grown with a fair degree of success under the more favorable conditions in adjoining dry-farming districts.

Soy-bean hay is nutritious and palatable to all kinds of livestock. In feeding value it is equal to any of the legume hays, but it can not compete with alfalfa or sweet clover in hay yield. Its high protein content makes it valuable for feeding with corn or other feeds high in carbohydrates.

Soy beans are used to a considerable extent for pasturage, particularly in mixture with corn (fig. 6), although so far as gross tonnage is concerned the results at Redfield indicate that nothing is to be gained by this practice. In planting soy beans and corn together, varieties that mature at about the same time should be used. As a result of tests made at Redfield it is rather evident that under these conditions soy beans are not suited to growing in mixture with millet, sorghum, or Sudan grass.

Ground soy beans are successfully employed with minerals as a substitute for tankage in feeding hogs and are meeting with uniform success in rations for poultry, sheep, and cattle, especially dairy cows. The straw has proved of value as a roughage for horses, cattle, and sheep.

In regions of limited rainfall, planting rows spaced 30 to 42 inches apart are best.

FIG. 5.—The soy bean is an annual grain, pasture, and hay legume of promise for productive cornlands in eastern Nebraska and eastern South Dakota

VARIETIES

Thirty-nine introductions of soy beans were under test at the Redfield station in 1914 and 1915, and of this number 12 have been retained as promising. The average seed yields per acre of the better-known varieties for 12 years are as follows: Mandarin, 11.7 bushels; Pinpu, 11.4 bushels; Manchu, 12 bushels; Aksarben, 11.4 bushels.

The Wisconsin Black is the earliest maturing variety tested. It is black seeded, matures in about 100 days, and ordinarily may be grown safely for seed as far north as southern North Dakota. At Redfield the growth has been smaller and the seed yield less than of the other varieties considered.

The Mandarin, a yellow-seeded variety, has been the most satisfactory for seed production at Redfield. It is well suited to northeastern South Dakota for seed production and as far north as south-

ern North Dakota for hay and pasture. It requires about 105 days to mature and yields almost as well as the longer season varieties such as Manchu and Aksarben.

The Manchu, another yellow-seeded variety, has given somewhat larger yields of seed than the Mandarin at Redfield, but as it barely matures before killing frost the seed has not been of as good quality nor can it be regarded as a safe variety this far north. It has been one of the most satisfactory varieties for hay, pasture, and silage, and is well suited for these purposes in northeastern South Dakota. In southeastern South Dakota and eastern Nebraska it is also a very valuable seed variety.

The Aksarben, a yellow-seeded variety, yields well at Redfield, but requires a little longer growing season than the Manchu.

FIG. 6.—A mixed sowing of soy beans and corn in wide rows furnishes pasture and silage of excellent quality

PLACE IN THE CROPPING SYSTEM

Soy beans may follow almost any crop, provided the land is properly prepared. On heavy soils they do especially well after field peas and sweet clover. When grown in cultivated rows the land is left in excellent shape for sowing alfalfa, sweet clover, and small grain the following spring and may usually be prepared for these crops by disking and harrowing. In the southern part of the region the early varieties mature in time for sowing the land to winter wheat or rye.

TIME, RATE, AND DEPTH OF SOWING

Soy beans should be sown at corn-planting time or as soon thereafter as the seed bed can be prepared.

Close-drilled rows require from 60 to 90 pounds of medium-sized seed to the acre. In rows 28 to 44 inches apart the rate varies from 15 to 45 pounds, depending upon the width of rows, size of seed, and moisture conditions. When drilled with corn, from 2 to 3 pounds of medium-sized seed per acre will be required, which allows about two beans to one kernel of corn.

Care must be taken to see that the seed is planted at the proper depth, which may be as much as 3 inches on light soils or under dry conditions, whereas 1 inch will generally suffice on moist clay loams.

CULTIVATION

When crust forms on the soil it may be necessary to break it, preferably with the weeder, rotary hoe, or harrow, before the plants emerge. After that the cultural treatment in rows should be practically the same as for corn. For broadcast or close-drilled plantings the weeder, rotary hoe, or harrow may be used. The soil should be stirred frequently enough to keep down weeds and maintain a good tilth until the plants are in bloom.

HAY AND SILAGE PRODUCTION

Soy beans should be harvested for hay when the seeds are about one-half formed and for silage when the pods are well filled. When put in the silo the usual practice is to mix about one load of soy beans to two or three of corn as the material goes through the cutter, although they may be ensiled alone with good results. The harvesting operations are very similar to those employed with other legumes.

SEED PRODUCTION

Soy beans should be harvested for seed when fully three-fourths of the leaves have dropped and most of the pods have turned color.

Plants of good height are most satisfactorily harvested with the grain binder or reaper. A mower with a buncher attachment may also be utilized. Shattering is much less if the crop is harvested while slightly damp. The bean and pea thresher is used for threshing. The grain thresher may be made to do fairly good work by removing the concaves and reducing the speed of the cylinder. Small lots of soy beans are sometimes flailed out.

A large acreage of soy beans may justify the purchase of a soy-bean harvester, which both harvests and threshes, but where this machine is used it is necessary to allow the plants to reach full maturity. This results in considerable shattering. However, if hogs are allowed access to the fields after harvest the waste will be small.

TEPARY, NAVY, AND GREAT NORTHERN BEANS

The tepary bean (*Phaseolus acutifolius* var. *latifolius*) is a low-growing vining plant with a seed similar to that of the navy bean (*P. vulgaris*), but considerably smaller. It has been grown for a long time for human food, particularly by the Indians in the southwestern United States. The first planting at the Redfield station was in 1914, but for the following four years the crop did not appear of

much promise, since only a small percentage of the plants matured seed. Subsequently seed yields have been relatively greater, but from 1920 to 1925, inclusive, they exceeded those of any other bean crop. It appears that this bean has rapidly become adapted through a natural elimination of the plants which did not mature, resulting in earlier and more even ripening. In time it may become a crop of value under northern dry-farming conditions. The seedlings emerge quickly, thus greatly assisting in effective early cultivation. The average seed yield of tepary beans at Redfield over a period of six years was 19.2 bushels to the acre. Aside from the value of this bean for seed production the straw is of some value as a feed for livestock.

The navy bean, the seed of which is a valuable human food, may be grown with a fair degree of success over the eastern third of this region. A deep, fertile, and well-drained loam with abundant organic matter produces the best yields. The average seed yield of the navy bean at Redfield over a period of six years was 7.9 bushels to the acre.

The seed of the Great Northern bean is larger but otherwise similar in appearance and food value to the navy bean. At Redfield it has been easier to obtain good stands of Great Northern than of the navy bean. Their climatic and soil requirements are similar. Over a period of six years at this station Great Northern beans gave an average yield of 11 bushels to the acre. The culls and the straw from the navy and the Great Northern may be fed to livestock with profit.

Seed-bed preparation, planting, and cultivation of the tepary, navy, and Great Northern beans are similar to those of soy beans grown for seed. More difficulty is likely to be experienced in obtaining good, even stands, however, unless the seed planted is carefully graded, as some drills are unable to handle it satisfactorily if it is irregular in shape and size.

COWPEAS

The cowpea is an annual legume that is valuable for hay, pasturage, seed production, and as a soil-improving crop in the Southern States. It does well on a wide variety of soils, but requires a long, warm growing season for maximum yields. Success has not thus far attended its culture in any portion of this region. The behavior of the crop varies greatly with the season. Most years the growth is small and the seed yields very low, but there are occasional seasons when the returns of both forage and seed are very satisfactory. In the long, hot, dry season of 1921 at Redfield the Early Buff, an early-maturing variety, yielded 16.9 bushels of seed to the acre. The 4-year average seed yield of this variety, however, was 10.7 bushels to the acre, as compared with 4.5 bushels of New Era, a rather later maturing variety, and 14.8 bushels of Mandarin soy beans. The failure of the cowpea to produce satisfactorily is probably due to the relatively short and cool growing seasons.

ANNUAL HAY AND PASTURE GRASSES

The principal cultivated annual hay and pasture grasses in this region are the small grains, foxtail millet, and Sudan grass. The

small grains and millet are quite generally adapted to these conditions, but Sudan grass is suited to more restricted areas in southern North Dakota and southward. The total area devoted to the grasses is small, but each will doubtless continue to serve as a very useful emergency hay and pasture plant when there is a shortage of the regular crops.

PLACE IN THE CROPPING SYSTEM

Small grains for forage occupy the same place in the cropping system that they would if grown for seed. Land previously in cultivated crops like corn furnishes the best seed bed. Small grain is usually best followed by winter wheat, winter rye, or a tilled crop.

As millet and Sudan grass are utilized almost exclusively as "catch crops," they seldom have a place in the farm rotation but are grown after winter grain, where an early sown crop has failed, or on lands that can not be prepared in time for putting in the regular farm crops. Almost any crop may precede millet and Sudan grass, but they often prove detrimental to the following crops.

SMALL GRAINS FOR FORAGE

The small grains are not commonly regarded as forage crops, but very frequently grain-producing possibilities are destroyed or so impaired by extreme drought that they may be more advantageously utilized for hay. Although wheat and barley often furnish excellent hay, oats generally yield more and are of better quality. Yields that may be expected are indicated by those obtained at Redfield during a 3-year period, when wheat gave an average of 2.49 tons of air-dry hay to the acre, as compared with 2.68 tons of barley and 2.96 tons of oats. When barley is grown for hay a beardless variety should be used. Early varieties generally do better under dry-farming conditions and where the season is short, while late varieties will give larger returns in long seasons and under more favorable moisture conditions.

The culture of small-grain crops for forage is identical with that for seed production. They are harvested for hay in the late milk or early dough stage and cured in the usual way.

Very satisfactory pastures, hays, and silages are sometimes obtained by sowing the small grains in combination with legumes, notably field peas.

FOXTAIL MILLET

Foxtail millet is the most easily grown and important of the annual fine-stemmed hay and pasture grasses of this region. (Fig. 7.) As types differ widely in the quantity and character of growth and the length of time required to reach maturity, varieties may be found that are suited to climatic conditions in nearly all portions of this region where crop production is feasible. They will grow on a wide variety of soils, but prefer a warm, moist, well-drained loam, rich in plant food.

The foxtail millets are the most dependable of the emergency hay crops, and good yields are obtained except in the most unfavorable seasons. The average air-dry hay yield of the Kursk variety over a period of four years at Redfield was 2.79 tons to the acre. Millet

hay may be used in limited quantities in a maintenance ration for all classes of livestock except horses, when especial care must be exercised to use hay cut in early bloom and to refrain from feeding it in excessive quantities and for extended periods.

Millet is sometimes used as an emergency pasture crop, being available for this purpose within a few weeks after sowing. It is, however, slow in second growth, does not form a sod sufficiently firm to withstand the trampling of animals, nor do the plants at first root securely enough in the soil to prevent their being pulled out when grazed. It is a poor substitute for good pasture, but may be used for this purpose during a shortage of the regular pasture crops.

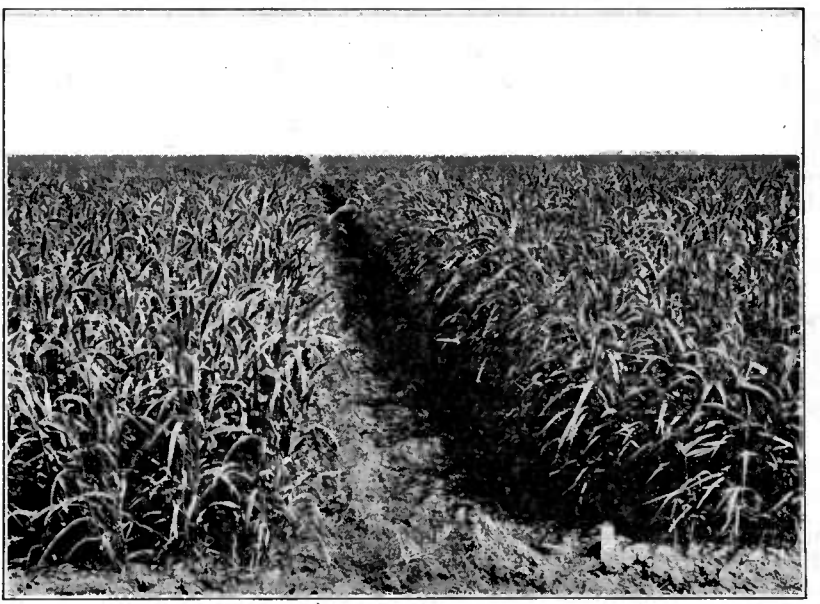

FIG. 7.—The foxtail millets are quick-growing and heavy yielding emergency hay and pasture grasses of value over the entire region

Foxtail millet seed is produced largely for the purpose of resowing. It is often used in poultry rations, but does not otherwise enter into the feeding of farm animals.

VARIETIES

Gold Mine, Kursk, Hungarian, Siberian, Common, and early-maturing Turkestan varieties of millet produced average hay yields over a period of nine years at Redfield, ranging from 2.6 to 3.1 tons to the acre. The early-maturing varieties, such as Common, Siberian, and Kursk, are the best for the northern and more arid conditions. The later maturing varieties, such as Gold Mine, Hungarian, and Turkestan, are larger growing and yield better in southeastern South Dakota and eastern Nebraska, where moisture is more abundant and the season is of sufficient length.

The seven-year average seed yield of the best four varieties of millet at Redfield varied from 18.8 to 20.7 bushels to the acre. Kursk, Siberian, and Common millet ordinarily mature seed over practically the entire region and Gold Mine and Hungarian in South Dakota and Nebraska.

TIME, RATE, AND DEPTH OF SOWING

It is customary to sow millet as soon as the soil is warm and can be put in good tilth. The best average yields at Redfield have been obtained from sowings made during the first days of June, but favorable moisture conditions have resulted in satisfactory returns from sowings as late as June 20. Under humid conditions it is to be expected that sowings even later than these may often be made advantageously.

The differences in average hay yields of Kursk millet from sowings at rates of 15, 20, 25, and 30 pounds to the acre over a five-year period at Redfield have been insignificant, only varying from 3.01 to 3.12 tons to the acre. From 15 to 20 pounds per acre of small-seeded millet and 20 to 25 pounds of large-seeded millet are best when the soil is in good tilth.

METHOD OF SOWING

Sowings of millet should be shallow, unless the soil is quite dry. The seed may be sown with an alfalfa and clover drill or from the grass-seeder attachment of a grain drill. If a drill is not available and moisture conditions are favorable the seed may be broadcast by hand or with a seeder and covered by light harrowing.

HAY PRODUCTION

As forage for horses, millet should be cut in the early bloom stage, but for general use the crop may be harvested with best results just after blooming. Delay in cutting results in a less palatable hay of reduced feeding value. The crop is easily harvested and handled by the regular haying machinery.

SEED PRODUCTION

For seed production millet is left until the grain shells readily in the hand. The crop may be harvested and threshed with the regular grain machinery.

Millet seed, grown for the purpose of resowing, requires extra care in order to maintain its purity. For seed production the seed should be as thoroughly cleaned as practicable and then sown on a clean seed bed. Pigeon grass is one of the most common weeds in this region, and as its seed is very difficult to remove from that of millet it is especially important that the final preparation of the land be sufficiently late to destroy pigeon-grass seedlings.

SUDAN GRASS

Sudan grass is a fine-stemmed sorghum, useful as an emergency hay and summer pasture crop. (Fig. 8.) It is not so generally

suited as millet to widely varying soil and climatic conditions, but under those to which it is adapted the greater feeding value of the forage more than compensates for the added difficulty of growing it. The largest returns are produced on deep, rich, well-drained loams in that part of Nebraska and South Dakota lying east of the ninety-eighth meridian. It seems probable that it will not be grown much north of the southern quarter of North Dakota or in the drier portions of these States, except in favored locations.

Sudan-grass hay is nutritious and is much relished by livestock, especially horses and cattle. It is more palatable than millet, and like that crop is better fed with the leguminous hays, which are high in protein. Average yields of 2.3 tons of air-dry Sudan-grass hay to the acre were obtained over a period of four years at Redfield, as compared with 2.78 tons of Kursk millet.

FIG. 8.—Sudan grass is an emergency hay and pasture grass excelling millet in feeding value. It is suited to the more favorable soil and moisture conditions in southern North Dakota and southward

The use of Sudan grass as an emergency summer pasture for all kinds of livestock is being very generally advocated. It has three decided advantages over millet in that it roots more firmly, it can be pastured over a longer period of time, and it is more palatable. The crop also provides good grazing after a cutting of hay has been removed. Sudan grass may be pastured with slight danger of prussic-acid poisoning, except when the growth is stunted by drought or other untoward factors. It excels broadcast and close-drilled sowings of Amber sorgo in all respects for pasture.

TIME, RATE, AND DEPTH OF SOWING

From 70 to 75 days are required to grow a crop of Sudan-grass hay and 115 to 120 days to mature seed. The length of the season may be reduced as much as 10 to 15 days, however, where the rainfall is limited.

The best time for sowing for hay production is between May 15 and June 1. Early sowing, although more weedy, may be expected to give the best yields when midseason drought is very pronounced and comparatively late sowings under the more favorable moisture conditions. The average yield of field-cured hay from May 1 sowing at Redfield for five years was 2.75 tons to the acre, May 15 sowing 2.87 tons, June 1 sowing 3.05 tons, and June 15 sowing 2.76 tons. For seed production it is advisable to sow as soon as the soil is sufficiently warm for seed germination and plant growth, which will usually be not later than June 1 in this region.

Close-drill or broadcast sowings at the rate of from 20 to 25 pounds of seed to the acre give the better results under humid conditions, whereas as little as 15 pounds to the acre may be advisable where the rainfall is limited. Over a period of five years at Redfield the average yields of field-cured hay per acre from sowings at rates of from 15 to 30 pounds have only varied from 2.68 to 2.89 tons. Sudan grass tillers freely and is capable of utilizing much space, but thin stands, coarse stems, and weediness are likely to result from attempts at sowing less than 15 pounds per acre. Sowings in widely spaced rows will require from 2 to 6 pounds of seed to the acre.

The depth of sowing should not exceed 1½ inches unless it is necessary to plant deeper to reach moisture.

METHOD OF SOWING

Sowings have been made at Redfield for 10 seasons to determine whether Sudan-grass hay can be economically produced in clean-cultivated rows 42 inches apart. This method of growing has made an average seasonal yield of 2.18 tons of hay to the acre, field cured, as compared with 3.15 tons from broadcast sowings, indicating that close-drilled or broadcast sowings are the most economical for hay production under humid and the more favorable dry-farming conditions. In growing for seed in localities of small rainfall, however, widely spaced cultivated rows have generally proved desirable.

A broadcast seeder or grain drill is best for sowing Sudan grass. Broadcasting by hand and covering with the harrow may be employed when mechanical seeders are not available. The grain drill may also be used for widely spaced drilled rows by closing a part of the seed cups. If cultivation is likely to be required before the seedlings emerge, sowings with a corn planter, for which special plates may be obtained, or a form of drill that will mark the rows will be necessary.

CULTIVATION

The seed bed for Sudan grass should be thoroughly prepared, as the early plant growth is often rather slow and is easily overcome by weeds. A weeder or light harrow may be employed to break any crust that forms after a packing rain. If planting has been done with a corn planter, so that the rows are well marked, cultivation with corn cultivators before seedlings emerge may prove desirable. The first cultivation should be comparatively deep and close to the row and later cultivation shallow and of sufficient frequency to keep down weed growth and maintain good soil tilth.

HAY PRODUCTION

Sudan grass is cut for hay from the time it starts heading until fully headed. When the growth is rank it is best harvested with a mower and handled like any other hay crop, but when short the crop may be harvested with a grain binder, as the great saving of labor involved in handling more than compensates for the added cost. The bundles should be allowed to cure a few hours before being placed in shocks.

SEED PRODUCTION

Sudan grass may be grown for seed with a fair degree of success in the southeastern portion of this region. The short growing season in the northern part and the uncertainties of precipitation in the central and western localities preclude the possibility of its ever being grown extensively for seed within these districts. Advantage may sometimes be taken of favorable seasons and a profitable seed crop harvested from fields intended for forage.

Sudan grass is harvested for seed when practically mature. Harvesting before too ripe or when slightly damp will prevent a great amount of shattering.

Under humid conditions the crop may be sown broadcast or in close drills for seed, harvested with a grain binder, and handled and threshed as small grain. In the dry-farming areas sowings should be in rows a sufficient distance apart to permit harvesting with a corn binder, if not with a grain binder, after which it may be handled as small grain.

PERENNIAL MEADOW AND PASTURE GRASSES

Cultivated perennial grasses occupy only a very small percentage of the acreage of this region, whether sown alone or as a constituent of permanent meadow and pasture mixtures. Timothy is the most important and universally grown of the meadow grasses, but being best adapted to a cool moist climate, its use as a hay in this region is almost wholly east of the ninety-eighth meridian. Many other well-known perennial grasses have some value where timothy is successfully grown, but in the dry-farming districts they can seldom compete with native grasses, and their use must necessarily be confined to the more favored soils and locations.

The most promising perennial grasses for dry-farming conditions are awnless brome, slender wheat, and crested wheat. Over a period of three years at Redfield, brome grass has given an average air-dry hay yield of 1.42 tons of hay to the acre as compared with 1.59 tons of slender wheat grass and 1.27 tons of crested wheat grass.

Awnless brome grass is quite generally adapted to the region. It is very resistant to cold and is one of the best cultivated perennial grasses available where moisture is limited. The plants are erect growing, have strong, aggressive rootstocks, and soon form a firm sod. Brome grass furnishes a fair quality of hay that is eaten by all classes of livestock, but because of certain laxative effects it is not extensively fed to horses. Feeders generally agree that it is slightly inferior to timothy. The yields of hay are usually very satisfactory the second and third seasons after planting. After the third season

the yields decline considerably, and it is better to pasture or plow the field. Brome grass is of chief importance as an early spring and late fall pasture, but with sufficient moisture it may make considerable mid-season growth. It is greatly relished by all classes of livestock.

Slender wheat is a native grass that has been brought under cultivation. It is easily established and furnishes pasture and hay of good quality. In an exceptionally wet spring at Redfield this grass gave a yield of 1.7 tons of field-cured hay to the acre the year it was sown. Brome grass and crested wheat sown under similar conditions the same season failed to produce a crop of hay. As with brome grass, yields decrease rapidly after the second or third season, and fields may be better utilized for grazing purposes.

Crested wheat is an imported perennial hay and pasture grass which shows promise as a competitor of brome grass in the region to which it is adapted. The hay is relished by livestock. This grass starts growth very early in the spring, seeming to excel brome grass in this respect, and does equally well as a late fall pasture. At Redfield in 1922 crested wheat, in a mixture with timothy on low moist land, returned 3.48 tons per acre of field-cured hay. This was the second year from sowing, and as the spring was unusually wet and cool the returns are more indicative of what may be expected under humid conditions.

Sowing in mixture with legumes and other grasses may add to the value of pastures and meadows in the more humid parts of this region. Yields of hay indicative of what may be expected under dry-farming conditions are shown in results obtained at Redfield over a period of nine years when one cutting each season of a mixed sowing of brome grass and alfalfa gave an average yield of 1.36 tons to the acre, as compared with 1.55 tons from alfalfa sown alone. The second and third seasons from sowing, the mixed planting greatly exceeded the yield of alfalfa alone, but the following years the differences were reversed, due apparently to the brome grass becoming sod bound, thus crowding out the alfalfa. Alfalfa and sweet clover are the legumes most generally used in grass mixtures. Alsike clover is also sometimes used, but can not be expected to persist beyond the second year.

PLACE IN THE CROPPING SYSTEM

The perennial grasses will fit anywhere in the cropping system where a comparatively firm and moist seed bed can be established for early spring sowing.

These grasses have a tendency to establish a heavy sod and improve soil texture, but the land is rather difficult to return to cultivation, especially during a dry period. Furthermore, unless the precipitation the season following breaking is very liberal the crops are likely to suffer from lack of moisture. Fall plowing of heavy sod can hardly be accomplished if the soil is very dry. Ordinarily the soil is in best condition for plowing in the early spring, but much more of the grass will volunteer than if plowed later in the season. At times of heavy rainfall perennial grasses at Redfield have been most effectively and economically killed out by plowing and preparing the seed bed just before sowing flax or barley.

TIME, RATE, AND DEPTH OF SOWING

Perennial grasses should be sown as early in the spring as the seed bed can be prepared.

The best rate of sowing varies in different localities, but for most conditions from 14 to 18 pounds of seed of brome and slender wheat and 12 to 15 pounds of timothy to the acre are satisfactory. From 7 to 8 pounds of brome grass or slender wheat to 5 or 6 pounds of alfalfa are sometimes recommended for a meadow and pasture mixture. For strictly pasture purposes sweet clover is a very acceptable addition and may be sown with brome grass at the rate of 8 to 12 pounds of brome to 6 to 10 pounds of sweet clover. These grasses and mixtures are best sown without nurse crops under dry-farming conditions, but where moisture is more abundant nurse crops are sometimes satisfactorily used. From 3 to 4 pecks of wheat, 4 to 5 of oats and barley, and 20 pounds of flaxseed per acre are the average rates of sowing of the nurse crops. The lighter sowings are advisable where nurse crops are used under the more arid conditions.

The depth of sowing perennial grasses will vary with the texture and surface moisture content of the soil, but ordinarily from one-fourth to one-half inch is a sufficient covering.

METHOD OF SOWING

Most of the grasses may be sown with a grain drill with grass-seeder attachment, either alone or in combination with one or more other crops. Seed that can not be sown with a drill may be broadcast immediately ahead of the drill or by hand and covered with a harrow.

CULTIVATION

The disking of pastures and meadows after they become sod bound has sometimes been recommended, but the results from such treatments have not been altogether satisfactory. Over a period of nine years at Redfield a yield of 1.30 tons of hay to the acre was obtained from a sowing of brome grass with alfalfa that was disked in early spring, as compared with a yield of 1.27 tons from untreated plots. No benefits were derived from disking during the second and third seasons, but afterwards a slightly better yield was obtained, although not enough to pay for the added labor involved.

HAY PRODUCTION

For the best quality of hay the perennial grasses should be cut just past the full-bloom stage. They are harvested and cured in the usual way.

PASTURE MANAGEMENT

Three factors seem most concerned in contributing to the injuries of perennial pasture; namely, too early pasturing in the spring, while the ground is soft and the grass so short that stock graze it very close; continuous grazing, the injuries of which may be avoided by dividing the pasture and pasturing only a portion at a time, thus

giving the plants a rest period; and overpasturing, which may be avoided by carrying a smaller number of animals on a given area. However, certain grasses having large rootstock development, like bluegrass and awnless brome, withstand closer grazing than the bunch grasses. A fair growth should be left in the fall for the protection of plants through the winter.

Yields obtained at Redfield, as previously described, show the desirability of turning fields of such grasses as awnless brome from meadows to pastures at the close of the second or third season.

SEED PRODUCTION

Perennial grasses should be harvested for seed when practically mature, using a grain header or binder. By cutting as high as possible with these machines, the stubble may be pastured or harvested

FIG. 9.—Corn (right) is the best and most generally adapted coarse fodder and silage plant in this region. Sorgo (left) is more drought resistant and is better suited to western Nebraska and southwestern South Dakota

for hay after removal of the seed crop and a fair quality of forage obtained. Better means of harvesting for seed not being available, the field may be mown, but a much greater loss of seed will result. The harvested crop should be placed in well-built stacks for drying. Threshing may be done with a grain separator by using special riddles and so regulating the machine as to cause the least possible seed waste.

COARSE FODDER AND SILAGE CROPS

The coarse fodder and silage crops of chief importance are corn and sorgo. (Fig. 9.) Sunflowers have been grown to some extent in the region, but in most cases the corn has produced at least as much dry matter and makes a more palatable silage. These are very valuable roughages where livestock is grown, and furnish the tilled crop necessary in a well-balanced cropping system.

PLACE IN THE CROPPING SYSTEM

Corn, sorghum, and sunflowers, which occupy the greater part of the cultivated area within this region, fit anywhere in a cropping system, but are usually best planted on sod or grain stubble. Under most conditions they are advantageously followed by small grain.

Corn is one of the least depressing of nonlegumes on the yields of the following crops, and practically all of them do well after it. Clean-cultivated cornfields furnish a firm and usually moist seed bed that can be quickly put in condition for an early sowing of alfalfa, clover, or the perennial grasses, with or without small grain.

The sorghums are considered rather hard on land. That sunflowers exert a most depressing influence on succeeding crops under dry-land conditions was indicated very conclusively at Redfield in 1921 and 1922. Corn and sunflowers after sunflowers both showed effects of drought much earlier than where they followed corn or small grain, and the ultimate growth was much less.

CORN

Corn is the most popular and important of tilled crops and is unexcelled for fodder and silage. It succeeds best in the southeastern part of the region, where the moisture conditions are most favorable and the season is relatively long and warm. One or more of the many types, however, may be profitably grown for some purpose over the greater portion of this region. Its adaptability is widening, and for fodder the crop is becoming increasingly important in the drier sections.

Corn fodder, having a high carbohydrate (sugar and starch) content, is most economically fed with grain and hays high in protein. Large yields are obtained from small areas, and it is the most easily harvested and handled of the crops of this nature. Silver King, a representative fodder corn, made an average yield at Redfield, over a period of four years, of 2.17 tons of air-dry fodder to the acre.

Corn silage is palatable, contains a high percentage of digestible nutrients, and will keep in good condition for a long period of time if properly ensiled. Supplementary grains and hays high in protein and mineral matter are generally added to the ration with profit. The silage yield of Rainbow Flint corn at Redfield, for a period of four years, averaged 10.51 tons.

Corn stover and stalks in fields from which the grain has been removed furnish a partially sustaining roughage for horses, cattle, and sheep.

VARIETIES

The use of varieties or strains that are sure to mature sufficiently for the purpose grown is essential for best results in fodder and silage production. In the purchase of seed corn it is generally advisable to select from the best neighboring field having similar soil conditions. Then by careful selection of seed each year a strain peculiarly suited to one's own conditions may soon be developed. A good fodder variety is leafy and an excellent producer of grain. The plants have few tillers and will be at the right stage for harvest

before frost. Leafiness and grain-producing qualities are also desirable in a silage corn, but the plants may tiller more freely and can be of a later maturing type than that grown for fodder or grain.

Golden Glow, Fulton Yellow Dent, Wimple Yellow Dent, Silver King, Minnesota 13, and native strains of Reid Yellow Dent are representative of the leading grain and fodder varieties of corn in the southeastern portion of this region. In North Dakota and western South Dakota, Northwestern Dent and Payne White Dent are standard varieties. Under the more favorable conditions the growing of early maturing dent varieties or strains extends to the Canadian boundary and through the central and western portions of these States. Although all corns make good silage, the flint varieties are

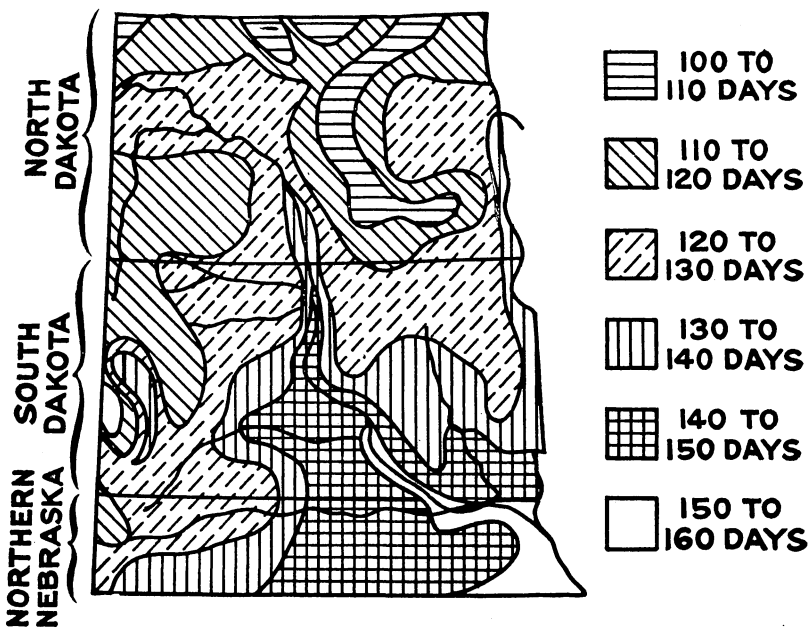

FIG. 10.—Map showing the available growing season (in days) during four-fifths of the years. The larger growing, later maturing varieties or strains of dent corn mentioned in the text are suited to the long season and abundant rainfall of eastern Nebraska and southeastern South Dakota. Early maturing varieties or strains are required for the short, cool seasons of the northern and the more arid conditions of western localities. (Based on map in Atlas of American Agriculture)

especially well suited for this purpose over the entire region, as they produce heavy yields of green matter and in feeding tests have not been excelled by other kinds. A standard variety of flint for southeastern localities is the large-growing, comparatively late-maturing Rainbow Flint, while a short-growing, early-maturing variety, such as Gehu Flint, is required in regions of low rainfall and where seasons are short and cool. (Fig. 10.)

PLANTING

Early planting of corn is desirable. It should be done in May as soon as the ground can be prepared and the soil is sufficiently warm to germinate the seed well.

Of the three methods of planting, checking in rows spaced 40 to 44 inches apart is preferable on the average farm, all things considered. By this method there is less ridging and the weeds are more easily controlled. It also contributes toward increased yields of subsequent crops. Drilling in rows 40 to 44 inches apart is a common method of planting and is the one more generally employed for fodder and silage production. Listing is practiced to some extent on level land and in loose or sandy soils, where there is much soil blowing.

The quantity of seed corn required for planting an acre is from 8 to 12 pounds. The depth of planting varies from about 1½ to 2 inches on the heavy soils to 3 to 4 inches on light soils. Dry soils require deeper planting than wet soils.

CULTIVATION

On soils of average texture corn may sometimes be harrowed or cultivated with good effect before seedlings emerge, especially when the soil packs or when a crust forms as a result of heavy rains. Harrowing is sometimes beneficial when corn is a few inches high, but the plants should be slightly wilted when this is done, so that they will not be broken. Two or three cultivations thereafter are usually sufficient.

HARVESTING FOR FODDER AND SILAGE

Corn should be harvested for fodder when the grain is beginning to glaze and while most of the lower leaves are still green. The most practicable means is with a corn binder, the bundles being allowed to dry partially before being shocked. Sleds with knife attachments especially designed for harvesting corn are sometimes used. Small areas are often harvested by hand, but this is not a desirable method when corn-harvesting machinery is available.

Corn is harvested for the silo while most of the lower leaves are green and the grain well glazed or dented. The crop is cut in the same way as for fodder. A low, flat-topped wagon will save much labor in loading bundles for hauling to the cutter.

SORGO

Under most conditions the better types of sorgo, or sweet sorghum, approximate corn in the production of fodder and silage and in feeding value. Greater difficulty is experienced in growing, harvesting, and handling sorgo. The climatic and soil requirements for maximum yields are identical with those of corn, namely, long and warm seasons, liberal and well-distributed rainfall, and deep, rich, well-drained soils. Sorgo succeeds under drier conditions than corn and is adapted particularly to the dry-farming sections of western Nebraska and southwestern South Dakota.

The greater portion of the sorgo is harvested for fodder and furnishes a palatable winter roughage for all classes of livestock. That sorgo fodder yields compare favorably with those of corn under the more favorable dry-farming conditions is indicated by the 4-year average air-dry returns at Redfield, when Dakota Amber, a representative northern variety, yielded 2.87 tons to the acre, Red Amber 3.12

tons, and Rainbow Flint corn 2.34 tons. Although outyielded in tonnage by Red Amber, the fodder from Dakota Amber and corn has usually been of the better quality at Redfield, as the seasons usually are not long enough to mature Red Amber.

A nutritious and palatable roughage for work animals is furnished when sorgo is close drilled or broadcast. The average air-dry yield at Redfield over a period of four years is 2.33 tons to the acre. (Fig. 11.)

Feeding results have shown sorgo silage to be of equal value to corn when fed to beef cattle, but of less value in milk production. Comparative yields of the two crops under Redfield conditions are indicated by air-dry weights over a period of two years, when Red Amber sorgo returned an average of 2.17 tons to the acre and Rainbow Flint corn 2.14 tons.

FIG. 11.—Sorgo sown broadcast or in close drills gives heavy yields in the southern part of the region

VARIETIES

A variety of sorgo should be grown for fodder and silage that will reach the proper stage of maturity before frost; otherwise a feed of inferior quality is produced. Judicious selection of early-maturing, comparatively dwarf sorgos with loose and open panicles of the Dakota Amber type will give the best results in the more northern and arid localities, whereas the larger growing sorgo of the Red Amber and Minnesota Amber type produce the larger returns in the southern and more favored locations. (Fig. 12.)

Over a period of four years at Redfield, Dakota Amber sorgo averaged 2.86 tons of air-dry fodder to the acre and Red Amber 3.11 tons. White milo, a grain sorghum, has also done very well as a fodder plant, giving an average yield of 2.62 tons to the acre.

TIME, RATE, AND DEPTH OF SOWING

The season for sorgo sowing follows that of corn and soy beans and is generally between May 25 and June 5.

From 3 to 4 pounds of seed to the acre are usually required for sowing widely spaced drilled rows and from 30 to 75 pounds for close-drilled or broadcast sowings. The sorgo plant adapts itself to the soil and moisture conditions under which it is grown and will tiller accordingly, so that an exact spacing is not so essential as with many crops.

The depth of sowing is from one-fourth to 2 inches, the deeper covering being necessary on the more open and drier soils.

METHOD OF SOWING

The seed is usually sown in widely spaced rows for fodder and silage and is sown broadcast or in close drills for coarse hay. At Redfield, Dakota Amber sorgo for a period of four years gave an average yield of 2.33 tons of air-dry cured hay to the acre from broadcast sowings, whereas rows 42 inches apart returned an average yield of 2.87 tons of coarse fodder to the acre.

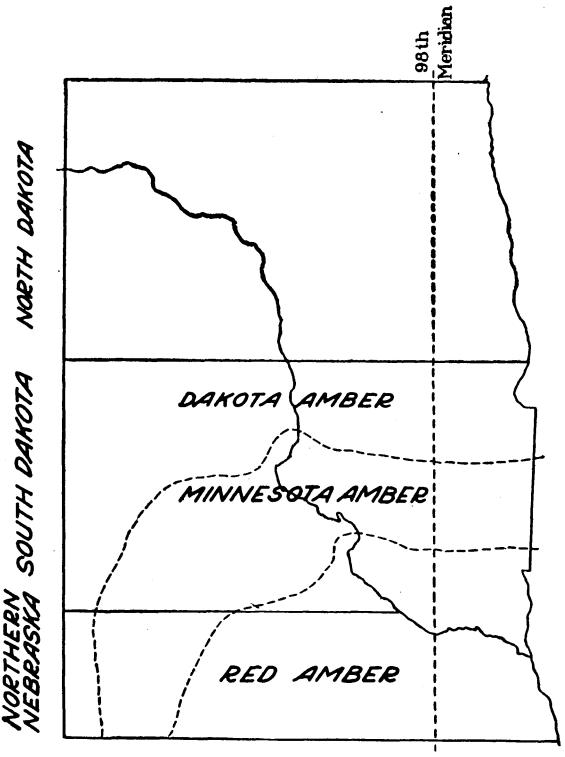

FIG. 12.—Map showing portions of the region in which the different varieties of the forage sorgos named may be expected to mature seed. North of the region indicated as suitable for the growing of Minnesota Amber, sorgo is of comparatively little importance

The seed may be planted with a grain drill, enough of the cups being closed to give the desired distance between the rows for wide spacings and allowing the seed to flow from all the cups for close sowings. The use of a corn planter with special plates is also a practicable means of planting in widely spaced rows; it has the added advantage of firming loose soils about the seed and marking the rows so as to permit cultivation before the plants emerge.

CULTIVATION

Good stands of sorgo are often difficult to obtain and early growth is unusually slow, necessitating great care in early cultivation. Cultivation of widely spaced rows just before the plants emerge and cross

harrowing soon after the sorgo is up are often desirable, especially if the soil is packed by rains or if the seed-bed preparation did not effectually destroy weeds. Later cultivations should be sufficiently frequent to insure good soil tilth and weed control.

HARVESTING

Sorgo is harvested for fodder and silage when the seed is in the hard dough stage, as the best quality of feed is obtained when plants are nearing maturity. The methods of harvesting are similar to those described for corn.

A well-advanced stage is desired for close-drilled or broadcast sowings for hay, but is usually not possible because of mid-season droughts which cause premature drying and necessitate immediate harvesting. When the mower is used the fields should be cut in dry weather and the hay left in the swath until the leaves begin to dry, then raked and cocked. Where the grain binder can be used the bundles should be allowed to lie for a time to cure and then should be shocked like small grain. This will result in a considerable saving in labor and spoilage. Stacking should be done as soon as possible, but not before the hay is well cured.

SEED PRODUCTION

Sorgo is narvested for seed when practically mature and before frost. On account of the freedom with which different kinds hybridize, the rogues in a field from which seed is to be selected should be removed as soon as apparent.

Small quantities of seed may be harvested by passing through the field and gathering the heads with a knife. These heads are then hung on wires or scattered on a floor to dry. After drying for a time they are in condition to be threshed. When seed is harvested in considerable quantity a row binder is used, if such a machine is available; otherwise the harvesting may be done by hand with a corn knife. The stalks are cut off near the ground and placed in shocks, where they remain until cured, after which the heads are cut from the stalks and threshed. Large areas are most economically harvested with a grain header and the harvested heads stacked in narrow ricks in the open for proper drying.

Threshing may be done with a small-grain thresher, with all but two or three of the concaves removed and the speed of the cylinder reduced to about two-thirds of that used for wheat.

SUNFLOWERS

Sunflowers have attracted considerable attention in the last few years as a cultivated silage crop and are promising for northern regions or those of high elevation where the seasons are too short and cool for successful corn production. (Fig. 13.) They are less resistant to drought and more difficult to harvest than corn, and these characteristics, with the slightly inferior quality of the silage and the depressing effects on subsequent crops, make them less valuable than corn and sorgo where these crops can be grown with a fair degree of success. Experimental data indicate that although sun-

flowers are not so particular as to soil as corn, they produce the largest returns on deep, rich soils.

The feeding value of well-prepared sunflower silage has been reported by various experiment stations as comparing favorably with corn, especially in a ration for dairy cows. The silage is not readily eaten at first, but animals soon become accustomed to it. Much of the success in feeding depends on cutting at the proper stage.

In comparative tests at Redfield over a period of three years Mammoth Russian sunflowers made an average yield, green weight, of 13.2 tons to the acre as compared with 10.5 tons of Rainbow Flint corn. The average yield of sunflowers for four years was 10.28 tons to the acre and of Rainbow Flint corn 10.51 tons. These yields might lead to the conclusion that sunflowers are practically equal to corn under conditions at Redfield, but when these weights are reduced

FIG. 13.—Sunflowers may be used to advantage for silage where the season is too short and cool for corn

to an air-dry basis, sunflowers are found to be outyielded by corn. Figured on an air-dry basis, the two years' average yield of sunflowers was 1.74 tons to the acre and that of Rainbow Flint corn 2.14 tons.

PLANTING

The best time for planting sunflowers is in late April or early May, the date varying somewhat with latitude and seasonal conditions. They are safely planted at Redfield about two weeks earlier than corn, as the young plants withstand lower temperatures without injury.

The plants should stand from 6 to 15 inches apart in the drilled row, the spacing depending upon soil and moisture conditions and the purpose for which the crop is grown. The wide rows and thin

stands are required for seed production, but for silage comparatively small stems are best, and plants should be relatively close. From 6 to 8 pounds of seed to the acre are required for drilled rows 24 to 30 inches apart and from 4 to 6 pounds to the acre for 40 to 44 inch rows.

The depth of planting in soil of average texture is from three-fourths to 1½ inches.

The grain drill is the most satisfactory implement for planting. The desired space between rows can be obtained by covering part of the cups. The corn planter may also be used. If the seed is graded no difficulty will be found in procuring suitable plates and adjusting the planter speed for proper distribution.

CULTIVATION

The cultivation of this crop is identical with that of corn. The seeds germinate quickly, and the young plants grow rapidly, so that less difficulty is experienced in keeping fields free of weeds than with many other crops that are planted in rows.

HARVESTING FOR SILAGE

It is important that sunflowers be harvested for silage at the proper stage, which is when from one-tenth to one-third in bloom. If left much later than this the stalks become woody.

The same method of harvesting for silage may be employed for sunflowers as for corn. The corn binder does excellent work unless the stalks are large and woody or unless the plants are lodged. Sleds with knife attachments are sometimes used, and small areas are harvested by hand. As the plants are disagreeable to handle, the use of machinery in harvesting and of low flat-topped wagons for loading and hauling the sunflowers to the cutter is highly desirable.

MISCELLANEOUS FORAGE CROPS

There are a number of other forage crops well adapted to restricted areas. The most important of these are rape, mangels, field carrots, sugar beets, and field pumpkins. Rutabagas and field turnips are of little promise under dry-farming conditions.

DWARF ESSEX RAPE

Dwarf Essex rape is a succulent, palatable, and nutritious annual pasture crop most generally used for hogs, sheep, and poultry. (Fig. 14.) Under favorable conditions pasturing may begin in early summer and may be prolonged into late fall by successive sowings. Rape does best in rather cool, moist weather, though it is capable of surviving relatively long periods of drought in mid season. East of the ninety-eighth meridian rape may be grown either broadcast or in widely spaced rows. In the dry-farming districts west of this meridian sowing in rows for all purposes is advisable.

The quantity of green forage that may be obtained from sowing in rows 36 inches apart under the more favorable dry-farming conditions is indicated by a 5-year average yield at Redfield of 7.6 tons to the acre. In 1923 and 1925 broadcast sowings yielded 8.41 tons of green matter as compared with 6.96 tons of rape in 36-inch rows.

There has generally been a second growth also that would have afforded considerable fall pasture. These returns compare favorably with other pasture crops, especially when the feeding value of the forage is considered.

Rape has been successfully grown with oats and barley for pasture. When sown with small grain either the growing plants are pastured or the stubble is so utilized after the removal of the hay or grain crop. Field peas have also been added to pasture mixtures under humid conditions with excellent results. Where moisture is abundant, one of the most popular and satisfactory practices is to sow rape in corn just before the last cultivation and hog it off in the late summer or fall.

FIG. 14.—Dwarf Essex rape is a palatable and nutritious annual pasture crop that is quite generally adapted to the eastern one-fourth of these States

PLACE IN THE CROPPING SYSTEM

Rape may take the place of any cultivated crop in the rotation without regard to preceding crops. It does especially well on old feeding grounds and field-pea, clover, and sod lands. The latter crops usually leave the soil in most excellent physical condition, and the seed bed seldom packs or crusts to such an extent as to prevent seedlings from breaking through.

TIME, RATE, AND DEPTH OF SOWING

The optimum date for the first sowing of rape will usually be as soon after April 15 as a good seed bed can be prepared, particularly under semiarid conditions. With favorable moisture, sowings may follow at about 15-day intervals for continued summer and fall pasturage, but planting later than June 1 is not usually feasible where extreme midseason drought is of common occurrence. Sowings of rape with small grain are made at the proper date for sowing the small grain, and in corn for hogging off just after a rain or at the time of the last cultivation.

Broadcast or close-drilled sowings of rape will require 3 to 8 pounds of seed to the acre; drilled rows 30 to 36 inches apart, from 2 to 3 pounds. In sowing with small grain from one-half to 1 bushel of oats or barley is sown with 2 to 4 pounds of rape. In combination with field peas for pasture, 3 pecks each of peas and oats and 4 pounds of rape approximate the average rate of sowing. The quantity of seed required for sowing in corn is from 2 to 5 pounds to the acre.

The seed of rape must not be covered to a depth exceeding one-half inch unless the ground is dry and loose.

METHOD OF SOWING

Rape may be sown with an alfalfa and clover drill, from the grass-seeder attachment of a grain drill, or it may be broadcast with a hand seeder or by hand. In utilizing the drill for sowing in rows the desired spacing may be obtained by closing part of the cups. The grain drill with grass-seeder attachment may also be utilized for sowing rape with small grain and field peas. The rape is sown from the grass-seeder attachment and the small grain and field peas from the grain box. When available, the 1-horse drill may be used for sowing in corn.

CULTIVATION

Fields sown broadcast or in close drills will not require cultivation, except possibly a harrowing to break any crust that may form and prevent young plants from emerging. Cultivation of widely spaced rows should begin as soon as the rows can be followed and should continue until the crop is ready for pasturing.

PASTURE MANAGEMENT

Rape grows rapidly and may be pastured when 10 to 14 inches high, which will usually be 8 to 12 weeks after sowing. Overgrazing may be avoided by sowing two or three fields or dividing a field with temporary fences to permit the crop in one field to grow while another is being pastured. Pasturing in corn is done when the corn is in the best stage for hogging off.

THOUSAND-HEADED KALE

Thousand-headed kale is a palatable and nutritious annual pasture plant, closely related to Dwarf Essex rape. Both crops require cool and moist weather for best growth, and practically identical cultural methods are employed. The pasturing periods are of about equal length, but the season for kale is a few days later. Kale has seemed the more drought resistant at Redfield. Over a period of five years at this station, kale made an average yield of 8.07 tons of green matter to the acre, as compared with 7.6 tons of rape.

ROOT CROPS

The root crops, the most important of which are mangels, stock carrots, sugar beets, rutabagas, and stock turnips, are succulent winter feeds grown as a substitute for silage. Because of the large amount of hand labor required for thinning and hoeing, the growing of any large acreage of these crops is prohibitive unless the farmer

has a family of children or an abundance of cheap labor is available. Mangels and sugar beets withstand mid-season drought and should yield well in favored locations over a considerable portion of the dry-farming area. Rutabagas and turnips are more susceptible to drought and the least promising of the common root crops for this region. Fertile soil, early planting, proper thinning, and thorough cultivation are essential for best results.

Root crops, especially mangels, are capable of returning very heavy yields under favorable conditions. At Redfield the 6-year average of the best-yielding variety of mangel is 19.69 tons to the acre, as compared with 7.69 tons of sugar beets, 5.49 tons of field carrots, and 5.77 tons of rutabagas. Field turnips have not been grown for so long a time, but the average return for three rather unfavorable seasons was 6.06 tons. The mangel is the only root crop that outyielded corn for silage in gross tonnage at this station, but on account of the very high moisture content of the mangel roots it is questionable if the crop outyielded corn in the quantity of dry matter produced. Corn silage has also a higher feeding value than roots.

MANGELS AND SUGAR BEETS

Mangels and sugar beets may be fed to sheep and hogs, but are of greatest value for dairy cows and poultry. At Redfield three well-known varieties over a period of six years gave average yields as follows: Mammoth Long Red, 19.69 tons to the acre; Danish Sludstrup, 16.1 tons; Golden Tankard, 10.65 tons. Sugar beets averaged 7.69 tons to the acre. The Mammoth Long Red mangel has yielded better than the short-growing and more globular or intermediate types in all seasons at this station, but is more difficult to harvest.

CARROTS

Carrots excel mangels and rutabagas but not sugar beets in food value and are especially valuable in rations for horses. At Redfield the average yields for six years were as follows: Oxheart, 5.49 tons; Mastodon, 4.56 tons; and Long Orange, 3.48 tons per acre. The short, thick type of carrot is seemingly better suited to the rather heavy clay soils. The slender, deep-rooted carrots are harvested with difficulty, as the roots usually break, resulting in a considerable loss in harvesting. On light soils and those of a sandy nature, however, the difficulties mentioned would not be encountered to nearly the same extent.

RUTABAGAS

Although seldom grown in the United States for this purpose, rutabagas are an excellent winter feed for beef cattle and sheep. They have, however, given rather unsatisfactory yields at Redfield. This six-year average yields of varieties were as follows: American Purple Top, 5.77 tons; Carter's Hardy Swede, 5.41 tons; and Hurst's Monarch, 4.06 tons.

TURNIPS

The uses of the turnip are similar to those of the rutabaga, and the same precautions should be taken in feeding. The Purple Top

White Globe variety at Redfield, over a period of three years, returned an average yield of 6.06 tons to the acre, as compared with 4.01 tons from the Purple Top Strap-Leaved. The yields of the latter variety were greatly reduced one season by disease.

PLACE OF ROOT CROPS IN THE CROPPING SYSTEM

Good yields of root crops may be obtained after field peas, clover, and small grain. On heavy soils such land is to be preferred to fields that were under cultivation the preceding season. On light and sandy soils they will best follow a clean cultivated crop. Root crops properly cultivated leave the land in excellent condition for planting to alfalfa, clover, and the perennial grasses.

SOWING

In the dry-farming region sowing is usually done to best advantage in late April or early May. Under humid conditions the optimum dates are generally a few days later.

The quantities of seed required for 1 acre are as follows: Turnips, 2 to 3 pounds; rutabagas, 3 to 4 pounds; carrots, 4 to 6 pounds; and mangels and sugar beets, 6 to 8 pounds. Sowing is done in rows varying from 30 to 44 inches apart, the spacing being made to conform to the cultivator employed. Depth of sowing carrots, rutabagas, and turnips under optimum conditions should be from one-fourth to one-half inch and mangels and sugar beets from one-fourth to 1 inch.

As the area that can be devoted to root crops is comparatively small, the 1-row garden drill will usually answer for sowing. Where the rows are widely enough spaced to permit the use of corn cultivators, the fields may be marked with a corn planter for sowing. This leaves a smooth track through which the drill may be pushed easily. The marks left by the drill and corn planter will also permit cultivation before the young plants emerge.

THINNING AND WEEDING

Root crops usually require thinning to insure roots of good size. Mangels and sugar beets should be 8 to 12 inches apart in the row, rutabagas and turnips 10 to 12 inches, and carrots 6 inches. Thinning must be done as soon as the plants are well established. The hoe will be of considerable assistance in cutting out plants, but will not obviate the necessity of considerable handwork. Only a small amount of additional hand labor will usually be required after one effective job of thinning and weeding.

CULTIVATION

Root crops require thorough cultivation to destroy weeds and to keep the soil in good tilth. On heavy soils crusting often prevents obtaining good stands of mangels, sugar beets, and carrots. A weeder may be used for breaking crusts soon after sowing, but after the seeds have germinated tools must be used with the greatest care.

HARVESTING AND STORING

Rutabagas and turnips are ready for use in early September, but the harvesting of carrots, mangels, and sugar beets should be delayed until late fall, just before danger of freezing. The potato digger has been successfully employed in harvesting turnips and rutabagas. The beet puller commonly used in sugar-beet growing regions will harvest mangels and sugar beets. Such machines are not generally available to growers of small areas, however, and it is usually necessary to resort to the use of plows and forks in harvesting. When machinery is not available for harvesting it may be desirable to grow the shorter and more globular-shaped mangels and carrots, because of the much greater ease of harvesting.

Roots for winter use should be topped and stored as soon as possible in a cool, dry, well-ventilated root cellar or pit.

FEEDING

Mangels and beets are fed whole to poultry. For other kinds of livestock the roots should be chopped fine or sliced and mixed with the grain ration before feeding. To prevent the flavoring of milk, rutabagas and turnips should be fed to dairy cows only in small quantities and preferably after milking.

FIELD PUMPKINS

Field pumpkins are valuable in the southeastern portion of the region as succulent fall and early winter feed for dairy cattle and hogs. The soil requirements are similar to those for corn, and they may be grown on the same land with little additional cost in money or labor. The time of sowing should follow closely that of corn. Sowing three to five seeds in the vacant hills of checked corn will usually furnish as many vines as desired, and the detrimental effects shown in the corn yields will be very slight. The plants will cause little trouble in cultivation if care is taken when sowing to make the hills in line with the corn rows both ways.

THE IMPORTANCE OF GOOD SEED

The importance of first procuring clean, viable seed of the crops to be grown can not be overestimated. Not only are thin stands resulting from poor seed germination unprofitable but the introduction of noxious weeds must be guarded against. Quack grass, for instance, is one of the most serious weed pests, and its seed is often found in brome-grass seed from sections in which this weed is prevalent. Seed of bindweed, wild oats, and wild mustard are other very undesirable weeds sometimes occurring as impurities. Germination and purity tests should always be obtained on seeds of doubtful character. The generally accepted weights to the bushel are as follows: Alfalfa, clover, field peas, and beans, 60 pounds; millet, 50 pounds; Sudan grass, 40 pounds; brome grass, 14 pounds; shelled corn, 56 pounds; Amber sorgo, 50 pounds; sunflowers, 24 pounds; Dwarf Essex rape, 50 pounds. Weights of seed of good quality should not be less than those given.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

March 28, 1927

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